LOW DENSITY PAPERBOARD SHEET AND TUBE INCORPORATING THE SAME

FIELD OF THE INVENTION

The invention relates to paperboard sheets, a process for making them, and to paperboard tubes made from such sheets.

BACKGROUND OF THE INVENTION

Paperboard is used in a wide variety of applications throughout numerous industries. For example, paperboard sheets are used as slip sheets for separating products, as a backing for laminates and as floor mats. Paperboard is also used to make partitions and roofing felt as needed for the construction of residential and commercial buildings. Additionally, paperboard sheet material can be wound into tubes and used as winding cores for winding filamentary materials such as yarns and threads, or for winding continuous sheet materials such as paper, plastic film, and metal foils or sheets. Such tubes can also be used to make containers for food products such as frozen juices, bread dough and snack products. Paperboard tubes are used as forms in the construction industry, e.g., for molding concrete columns and the like.

Often, the physical characteristics of individual paperboard sheets are tailored to a particular end use. For example, heavy-duty applications may require tubes produced from sheets of greater tensile or compressive strength. During paperboard production, strength, compressibility and absorption are physical properties commonly tailored to suit particular applications. Each of these properties is dependent to some extent on the density of the manufactured paperboard sheet. Relatively high-density paperboard tends to be stronger, less compressible and generally non-absorbent. Low-density sheets however, tend to be weaker, more compressible or sponge-like and thus capable of greater absorption. Apart from being uniquely suited to applications such as roofing felt or floor mats that require absorption and/or cushioning properties, the principal advantage of low-density paperboard is that it produces a greater volume of paperboard at a lower cost than stronger, denser paperboard.

Low-density paperboard is produced by preparing an aqueous slurry or "stock" that contains cellulose fibers, fillers and additives. The necessary cellulose fiber is generally drawn from waste paper such as recycled newsprint, magazines, scraps from old paperboard tubes and corrugated boxes. Apart from cellulose fiber, one known low-density paperboard, as disclosed by U.S. Patent No. 5,227,024 to Gomez, contains highly specialized vegetable or wood waste fillers. In order to be of use in traditional papermaking, according to Gomez, such fillers must undergo a costly refining or "micronization" process. Specifically, the vegetable or wood waste is pulverized such that the particles have mean dimensions smaller than 150 microns. Additionally, the filler is thoroughly dried such that its pre-grinding residual moisture content is less than 20 percent. The micronized filler is then added to the stock in a weight ratio of filler to fiber ranging from 1:10 to 5:10. Next, the stock is injected onto a forming wire. Water is drained from the stock through the forming wire so that a wet web of paper is left on the wire. The web is dewatered further in a press and then dried in a dryer.

Secondary operations, such as the micronization process described above, add additional and often prohibitive costs to papermaking. It is desirable then, to produce a low-cost, high-yield paperboard of relatively low-density and of moderate tensile strength that does not require filler micronization. Further, it is desirable that a low-density paperboard be produced from readily available materials so as to preserve any cost reductions while providing the broadest possible engineering flexibility and thereby potentially serving a range of applications.

BRIEF SUMMARY OF THE INVENTION

The present invention addresses the above needs and achieves other advantages by providing a low-density paperboard sheet of at least one paperboard layer made from a stock that includes a proportion of standard wood flour or fine sawdust in addition to traditional cellulose fibers. The proportion of sawdust can be up to 40% or more by weight. Advantageously, the sawdust of the present invention does not require a costly refining or micronization operation in order to produce low-density, high-yield paperboard sheets.

The fine sawdust described for use according to the present invention is of a type readily produced by thin curf band saw blades. Commercial sawmills commonly use these blades and, in fact, sell the desired sawdust daily by the ton, for use as boiler fuel. As mentioned above, the fine sawdust of the present invention does not require a costly micronization operation. Instead, only a simple sifting or screening step is needed to remove excessively large pieces of wood. The screened sawdust is then placed in the stock with the cellulose fibers. The stock is fed into a distribution chamber, also called a headbox, former, forming chamber, vat, or the like, depending on the paperboard making machine used. The distribution chamber injects the stock onto a forming wire, and provides the necessary turbulence to the stock to keep it well dispersed. The stock is dewatered through the forming wire, then pressed and dried as discussed above. The low-density paperboard of the present invention may be readily produced via standard papermaking machines that are commonly known in the art (e.g., fourdrinier, cylinder, etc.).

Standard paperboard making machines may be provided with multiple distribution chambers to produce paperboard sheets of multiple layers. A paperboard layer consists of a single web of paperboard material that has been injected onto a forming wire from a given distribution chamber as discussed above. Often, these individual webs or layers are removed from their respective forming wires and placed one atop the other, dewatered in a press and then dried. The layering of paperboard in this way encourages bonding between fibers of adjacent layers, thereby joining the layers firmly together and ultimately resulting in a unitary paperboard sheet. Alternatively, a multi-layer sheet can be produced by injecting multiple stock flows through a multiple-slice distribution chamber onto a forming wire.

In preferred embodiments of the present invention, low-density paperboard sheets may possess a single layer or multiple layers. In multiple-layer sheets, the various layers may be produced from stocks of differing sawdust filler concentrations. As a result, sheets may be produced that have layers of various densities. Relatively low-density paperboard, as referenced in this application, is that which has been produced from a stock having greater than 1 percent sawdust by weight. As described in greater detail below, layering paperboard of various densities allows paperboard designers to minimize

manufacturing costs while simultaneously tailoring the physical properties of their designs to meet the requirements of a given application.

For example, in one preferred embodiment of the present invention, paperboard sheets as described in this application may be converted into partitions, support posts, slip sheets, floor mats or the like which serve to protect delicate objects from damage. By incorporating the low-density paperboard of the present invention into the multi-layer sheets used to produce such applications, the desired cushioning properties may be attained without need for additional and often costly lining or coating operations.

In still other preferred embodiments of the present invention, the above-described paperboard sheets may be slit to a desired width to form low-density paperboard plies. Such plies may be convolutely or spirally wound about an axis to form a wound low-density paperboard tube. Such tubes may have an abundance of practical uses, among them may be as winding cores for plastic film or other similar elastic products that benefit from a moderately compressible winding core. Although generally having a circular cross-section, the tubes of the present invention may have any cross-section shape that can be formed by wrapping the tube around an appropriately shaped mandrel. For example, the tube can be formed in a rectangular shape with rounded corners.

DETAILED DESCRIPTION OF THE INVENTION

The present inventions now will be described more fully hereinafter. These inventions may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements.

For the purposes of this application, the below terms shall be defined as follows:

Layer - A paperboard layer comprises a single web of paperboard material formed from a given stock.

Sheet - A paperboard sheet comprises either a single layer of paperboard (in which case "sheet" and "layer" are interchangeable), or multiple layers of paperboard stacked atop one another and joined together to form a multi-layer structure; the various layers can be formed from the same or different stocks.

Ply – The term "ply" is essentially interchangeable with "sheet", except that "ply" is used when referring to an individual discrete sheet that is incorporated into a paperboard product such as a paperboard tube, partition, floor mat, slip sheet or the like. Thus, a paperboard tube may comprise multiple plies wound one atop another to form a "multi-ply" tube.

To produce paperboard sheets in accordance with the present invention, an aqueous slurry or "stock" is prepared containing cellulose fibers, fillers and additives. The primary "filler" used in accordance with the present invention is wood flour or fine sawdust. The sawdust is of a standard type, commonly sold by sawmills as boiler fuel. The sawdust is sifted with a .125 inch screen (3175 micron) to remove excessively large wood chips. The sifted sawdust is then placed in the stock with the cellulose fibers. The precise proportion of sawdust to fiber will change per application; however, most applications call for a sawdust content of an individual sheet ranging from 1% - 40% by weight. In a preferred embodiment of the present invention the sawdust content of a given sheet is between 1 and 6 % by weight. In another preferred embodiment, the sawdust content per sheet is between 10 and 20 % by weight. In yet another preferred embodiment, the sawdust content per individual sheet is between 1 and 30 % by weight.

As discussed above, the sawdust of the present invention advantageously does not require a micronization or pre-drying operation. Contrary to Gomez's finding that wood fillers must be pulverized to a mean particle size of less than 150 microns, it has been found that sawdust with a mean particle size ranging broadly from 350 microns to 3175 microns can be used effectively as a component in the paperboard of the present invention. In one preferred embodiment, 95 % of acceptable sawdust was too large to pass through a 354-micron screen. Additionally, with an acceptable residual moisture content as high as 30% - 50%, the sawdust of the present invention does not require extensive pre-drying operations.

Once the stock has been prepared to contain the appropriate sawdust concentration for the intended application, it is then injected from a distribution chamber onto a forming wire. Various types of papermaking processes can be used, including single-wire fourdrinier processes or multiple cylinder-type processes. Water is then drained from the stock through the forming wire so that a wet web of paper remains. The

web or layer of paperboard is dewatered further in a press section and then dried in a dryer section. The low-density sheet produced by this process may then be fed into a number of conversion operations that transform the sheet into products such as partitions, corrugated boxes, paperboard tubes or the like.

Typically, to produce a multi-layer sheet multiple vats of stock are prepared having potentially differing compositions. The stock can be injected from a multiple-slice distribution chamber to form a multi-layer sheet on a forming wire, or the various stocks may be injected by separate distribution chambers onto separate forming wires and the resulting sheets may then be brought into face-to-face contact, dewatered and dried, to form the multi-layer sheet.

In one preferred embodiment of the present invention, paperboard sheets include layers of differing sawdust filler concentrations so as to produce multi-layer paperboard sheets. For example, layers of relatively lower (or zero) filler concentration may be included to reinforce what would otherwise be relatively weak low-density sheets while simultaneously yielding material cost reductions. As noted above, such multi-layer formation provides paperboard designers with the flexibility to streamline their designs to possess only those physical properties required for a given application. For example, low-cost floor mats having ample padding (low-density layer) and a relatively non-absorbent upper surface (high-density layer) to prevent soiling, may readily be provided.

In yet another preferred embodiment, one or more relatively low-density layers may be sandwiched between two relatively high-density "liner" layers forming a paperboard sheet useful for nearly all of the paperboard applications described above. Advantageously, such "lined" sheets are often easier to manufacture than single layer low-density sheets as the high-density layers provide smooth surfaces that accommodate more intimate contact with paperboard machine dryer surfaces. Additionally, without high-density liner layers to hold them in, loose sawdust particles of isolated low-density layers may become dislodged or "slough off" as the paperboard web is handled in the paperboard-making machine, or subsequently as the web is incorporated into a product. This residual sawdust could be problematic as it may contaminate adhesive or other systems.

When relatively low-density layers are bonded to relatively high-density layers to produce multi-layer paperboard sheets in accordance with the present invention, it is desirable for paperboard manufacturers to select sawdust to fiber concentrations such that there is a significant difference between the densities of the resulting layers. For example, in one preferred embodiment of the present invention, there is at least a 1% difference in density between relatively low-density and relatively high-density layers, more preferably at least a 5 % difference, and still more preferably at least a 10 % difference.

In yet another preferred embodiment of the present invention, a low-density sheet having at least one low-density layer may be used as a ply in a wound paperboard tube. Tubes according to the present invention may be produced from one or more plies via spiral winding, or alternatively, may be produced from a single ply via convolute winding.

As discussed above, the sawdust composition directly impacts the density of the ply layers, which in turn directly impacts physical characteristics such as strength, compressibility and absorption. As a result, tube engineers are provided improved flexibility in tube design. For example, when designing tubes of moderate strength for a given application (e.g., snack containers), stronger, denser plies may be used to reinforce weaker, low-density plies so as to limit manufacturing costs while simultaneously ensuring adequate performance of the resulting tube. Additionally, tubes produced from relatively low-density plies may be selected for their relative elasticity. For example, winding cores used to roll plastic film are optimally produced from compressible materials having at least a moderate elasticity. This allows the stretched film, which is itself elastic, and subject to temperature induced expansion and contraction, to exert considerable force on the winding cores over time without damaging the cores.

Further advantages and characteristics of the present invention will be apparent from the following description of Examples, which do not imply a limitation but are given by way of illustration, showing the use of the wood sawdust of the present invention during the manufacture of paperboard.

5% AND 15 % SAWDUST EXAMPLES

To assess the relative strength and density imparted to sheets composed, in part, of wood sawdust according to the present invention, two distinct multi-layer sheets were prepared from stocks to which different proportions of sawdust were added for making the various layers of the sheets. Each multi-layer sheet was comprised of four layers and manufactured on a standard cylinder papermaking machine as is commonly known in the art. Each multi-layer sheet comprised two relatively low-density layers that were bonded to, and sandwiched between, two relatively high-density layers. The relatively low-density layers of Sheet 1 were comprised of 10% sawdust by weight, which equated to approximately 5% sawdust by weight of the resulting four-layer sheet. The relatively low-density layers of Sheet 2, however, were comprised of 30% sawdust by weight, which equated to approximately 15% sawdust by weight of the resulting four-layer sheet. The outer high-density layers of both Sheet 1 and Sheet 2 contained no wood sawdust. Once the sheets were produced, three samples were selected from each sheet. For each sample, the caliper or thickness, basis weight, density, and tensile strength in both the machine (MD) and cross-machine (CD) directions were measured. The results of these measurements were averaged for the three samples of each sheet and compared to "control" sheets that were comprised of four layers having no wood sawdust. The results of this comparison are provided in Table 1 below.

IDENTIFICATION	SHEET 1			SHEET 2		
	Control	5% Sawdust	% Change	Control	15% Sawdust	% Change
Caliper, mils.	30.3	30.4	0.3%	30.2	34.2	13.0%
BW, lbs/1000 sq.ft.	69.7	66.6	4.4%	83.5	77.5	7.2%
Density, lbs./pt.	2.298	2.190	4.7%	2.760	2.270	17.8%
Tensile, lbs/in MD	123.3	104.5	15.3%	141.0	102.5	27.3%
Tensile, psi MD	4055.3	3440.6	15.2%	4664.2	3001.0	35.7%
Tensile, lbs/in CD	36.0	31.5	12.5%	30.3	27.0	11.0%
Tensile, psi CD	1187.0	1036.6	12.7%	1002.3	790.8	21.1%

Table 1

As illustrated by Table 1, a relatively low-density, high-yield, paperboard sheet of at least moderate tensile strength may be produced according to the present invention. It should be noted, that the relatively high-density layers of Sheets 1 and 2 were produced

from control stocks having significantly differing densities. Accordingly, it is most useful to compare each relatively low-density sheet against their respective control sheet, rather than attempting to compare one against the other.

Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.